



Late Pliocene (Piacenzian Stage) Fossil Molluscs from Upper Siwalik Subgroup of Jammu, Jammu and Kashmir, India

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Abstract

Five species of gastropods and two of bivalves are being reported, and described from the mudstone horizon immediately underlying geochronologically dated (2.8 ± 0.56 m.y.) bentonitized tuff band exposed at Barakhetar village in a stream cutting section. The reported fauna comprises Gastropods: *Gastrocopta* sp., *Gyraulus* sp. indet., *Viviparus bengalensis*, *Viviparus* sp., *Bellamyia celispiralis* and Bivalves: *Lamellidens lewisi*, *Oxynaia* sp. indet. Stratigraphically, the fossil (gastropod and bivalve) bearing mudstone horizon belongs to the Nagrota Formation of Upper Siwalik Subgroup of Jammu Province, Jammu and Kashmir, India and located about 30 km east of Jammu city. A brief account of the age and palaeoecology of the recovered taxa have also been discussed in the present paper.

Keywords: Late Pliocene, Molluscs, Palaeoecology, Age, Nagrota Formation, Upper Siwalik Subgroup, Jammu,

Introduction

Siwalik Group is the southernmost part of the Himalayan foreland basin containing rich assemblage of Neogene fossils. It occurs all along the length of the Himalayan arc from the Indus River in the northwest to Brahmaputra in the east. Most of the type sections of the Siwalik Group occur in Pakistan; a few occur in India and reference sections that yield fossils are known from both India and Nepal. Bhatia and Mathur¹ have reported eleven taxa of bivalves and twenty two of gastropods from the Late Pleistocene of Punjab. Takayasu et al.² recovered freshwater Miocene – Pliocene molluscan fossils from the Churia Group (equivalent to the Siwalik Group) of Nepal. The recovered bivalve fauna comprises *Lamellidens arungensis*, *Lamellidens longiformis*, *Indonaia narayani*, *Indonaia jimuriensis*, *Indonaia tenella*, *Parreysia binaiensis*, *Parreysia zigzagicostata* and *Physunio chitwanensis*. Mathur³ described four taxa of gastropods and six of bivalves from the Middle and Upper Siwalik deposits (Late Miocene-Pleistocene) of Kangra (H.P.), Ambala (Hararyana), and Ropar (Punjab) districts. This fauna is represented by *Ammicola (Alocinma)* sp., cf. *A. (A.) sistanica*, *Sitala* sp. indet. (Upper Siwalik Pinjor Formation) and *Hydrobioides avarix* and *Indoplanorbis exustus* from terrace deposits. The bivalves are represented by *Parreysia* sp., cf. *P. edwini* (Gupta), *P.* sp. indet., *Lamellidens* sp. indet. A, *L.* sp. indet. B, *Oxynaia* sp. indet. (Pinjor) and *Corbicula* sp. from the Boulder Conglomerate Formation (Upper Siwalik). Mathur³ made an attempt to synthesise the sporadic records of charophytes from the Siwalik Group and to build up a molluscan biostratigraphy and concluding that the *Lamellidens prashadi* is of the proposed Lower Zone (Chinji) and *L. jammuensis* of the proposed Upper Zone (DhokPathan – Pinjor). Within *L. jammuensis* Zone, *L. subparallelus-Parreysia (Parreysia) tatrotensis* assemblage represents the Lower Sub

Zone (DhokPathan – Tatrot) and *Pisidium (Afropisidium) sivalensis* represents Upper Sub Zone (Pinjor). Gurung⁴ collected freshwater fossil molluscan fauna from the Siwalik Group of Nepal which is represented by gastropods belonging to the families Viviparidae, Ampullariidae, Bithyniidae, Thiariidae and bivalves belonging to the families Unionidae, Corbiculidae and Pisidiidae. Of these four new species viz. *Angulyagra schiddarthai*, *Brotia dobataensis*, *Paludomus suraiensis* and *Parreysia chureii* have also been described⁴.

The Siwalik succession of Jammu Hills, the eastern extension of Potwar Plateau and lying in a linear belt between the Line of Control and Ravi River, is relatively least studied area from invertebrate and micro- paleontological points of view. No reports have been published on gastropods and bivalves of this area until now except that of Prashad⁵ and Parmar⁶. Prashad⁵ collected two specimens of unionid shells from the Upper Siwalik beds near Nagrota, Jammu and one shell from Nawapet, Hyderabad, and Deccan India. The unionid fauna comprises of *Lamellidens jammuensis*, *Indonaia mittali*, and *Indnaia pascoei*. Parmar⁶ recovered a few species of molluscan fauna comprises of Mesogastropoda incertae sedis, *Lamellidens* indet., Thiariidae sp. *Parreysia tatrotensis* from the Lower Siwalik deposits of Jammu region. The present collection of bivalve and gastropod specimens have been recovered from the mudstone horizon immediately underlying the geochronologically dated bentonitized tuff band (2.8 ± 0.56 m.y.) exposed at Barakhetar village in the Nagrota Formation, Upper Siwalik Subgroup of Jammu region.

Repository: The recovered specimens have been lodged in the Department of Geology, Paleontology Laboratory, Jammu University under catalogue numbers DG/PL/JU/1-8.

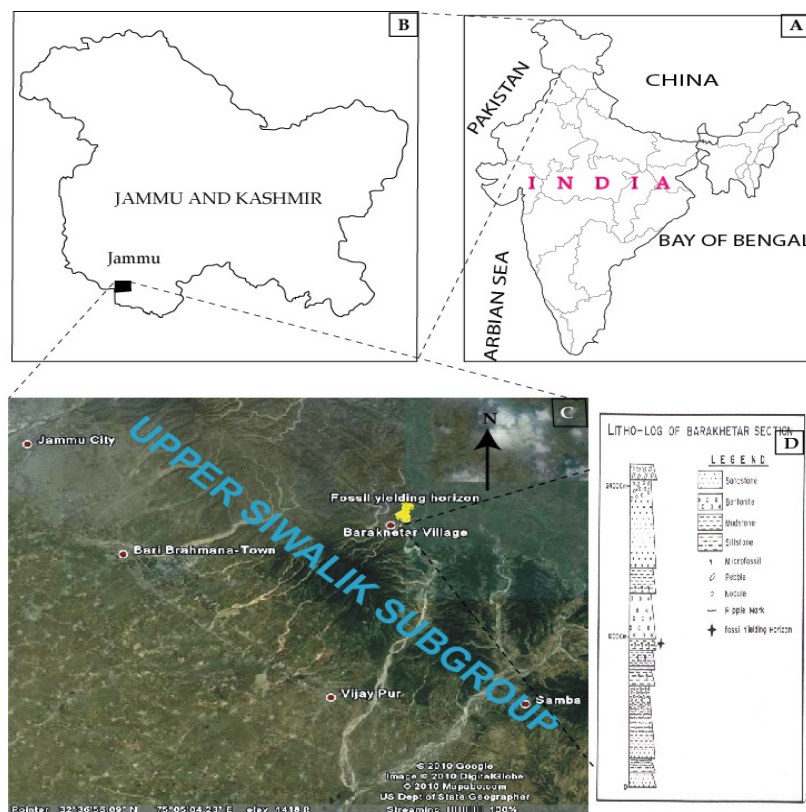


Figure 1

A. Map of India; B. Map of Jammu and Kashmir; C. Locality map of gastropods and bivalves bearing mudstone horizon (Reference Google earth) and D. Litho-Log of Barakhetar section showing position of fossil yielding horizon

Stratigraphy: From a long time many geoscientists Falconer⁷, Lydekker⁸, Colbert⁹, Lewis¹⁰, Wadia¹¹, Opdyke¹², Azzaroli and Napoleone¹³, Johnson¹⁴ have classified the Siwalik Group of rocks on the basis of one or more of lithology, fauna and flora, magnetostratigraphy and satellite imagery analysis. But the standard stratigraphy of the Siwalik rocks was provided by Pilgrim¹⁵ on the basis of the fauna recovered from Siwalik Hills. He divided the “Siwalik Series” into three units which could have subdivided into seven stages. i.e. Lower Siwalik (Kamlial Stage, Chinji Stage), Middle Siwalik (Nagri Stage, Dhok Pathan Stage) and Upper Siwalik (Tatrot Stage, Pinjor Stage and Boulder Conglomerate Stage) and these assigned an age ranging from Middle Miocene to Lower Pleistocene for the Siwalik Series. This classification is more or less followed till date. All these above stages are named on the basis of type sections in undivided India, but after the division of India most of the stages occur in different localities in Pakistan, except Pinjor and Boulder Conglomerate, which occur in India.

The Siwalik Group of Jammu division is exposed in outcrops that occupy an intermediate position between the type sections on the west and Siwalik Hills of Chandpur in east having type localities Pinjor and Boulder Conglomerate. Various lithostratigraphic units starting from Chinji Formation to Boulder Conglomerate Formation have been delineated in this area¹⁶. The Upper Siwalik Subgroup of rocks of Jammu region

has been divided into Parmandal Sandstone, Nagrota Formation, and Boulder Conglomerate¹⁷. Agarwal¹⁸ adopted these stratigraphic divisions and subdivided Nagrota Formation into three members i.e. Nagrota-A, Nagrota-B, and Nagrota-C. Gupta and Verma¹⁹ classified the Siwalik Group of Jammu into Mansar Formation (Lower Siwalik Subgroup); Dewal Formation (=Nagri), Mohargarh Formation (=Dhok Pathan) (Middle Siwalik Subgroup); and Uttarbehani Formation, Dughor Formation (=Boulder Conglomerate) (Upper Siwalik Subgroup). Gupta²⁰ further modified the latter classification and divided the Mansar Formation into Dodenal Member and Ramnagar Member and Uttarbehani Formation into Labli Member (=Tatrot) and Marikhui Member (=Pinjore). The comparative classification of Siwalik group of Jammu is given by various workers is reproduced in the table-1.

Systematic Description

Phylum	Mollusca
Class	Gastropoda
Order	Caenogastropoda
Family	Viviparidae
Genus	<i>Viviparus</i>

Viviparus bengalensis: Referred Material: DG/PL/JU/01, one shell. Stratigraphic Position: Mudstone horizon immediately underlying the geochronologically dated (2.8 ±0.56 m.y.)

bentonitized tuff band exposed at BaraKhetar, Jammu. Locality: In a stream cutting, 0.375 km northwest of BaraKhetar village, Jammu district, Jammu and Kashmir, India. Description: Shell short and broad, conical spire, four whorls, whorls swollen, dextrally coiled increase in size gradually and evenly, body whorl larger than the spire, suture linear and impressed, surface of whorls convexly flattened, aperture subspherical, ventral surface of the body whorl convex, surface smooth.

Remarks: The present forms approach the morphology of *Viviparus bengalensis*, which has so far been recorded from the Pleistocene deposits of Narmada valley²¹ and Pinjor Formation near Chandigarh²² and Saketi³. It has also been documented from the freshwater lakes of Jammu region²³ and has a wide spread occurrence in the Indian subcontinent.

Viviparus sp.: Referred Material: DG/PL/JU/02, one shell. Description: Shell small, medium-sized, slightly inflated, short conical, apex blunt, three whorls, whorls increase in size gradually and evenly, body whorl higher than spire, whorls moderately convex, sutures linear and depressed, aperture ovoidal in shape, ventral surface of body whorl convex, dextrally coiled, a low prominent ridge along the basal periphery of ultimate whorl, surface with fine longitudinal striae.

Remarks: The specimens under discussion differ from those of *V. bengalensis* in having adpressed sutures, less inflated whorls, and ovoidal aperture. Although in general appearance, the present specimen resembles *Sitala* sp. indet. from Pinjor Formation near Chandigarh³, is elongate conical and the number of whorls are $5\frac{1}{2}$, the spire is relatively high and the apical angle is low.

Order Mesogastropoda
Genus *Bellamyia*

Bellamyia celsipiralis: Referred Material: DG/PL/JU/03, one specimen. Description: Shell elongated turbinata in shape, moderately solid, spire elevated, long, equal or slightly larger than the body whorl. Shell consisting of four whorls, gradually and regularly increase in size. The whorls are rounded and separated by impressed suture. Aperture partially preserved, body whorl not greatly enlarged in size. Shell surface marked with coarse and fine striate or growth lines. Aperture broadly ovate, small, thinly lipped, inner lip is thicker than the outer lip.

Remarks: The specimen under study compares well with *Bellamyia celsipiralis* described by Gurung²⁴ from the Churia (Siwalik) Group of Tinnai (Nepal).
Genus *Gyraulus*

Gyraulus sp. indet.: Referred Material: DG/PL/JU/05, one specimen. Description: Shell small in size, 2-4 mm in diameter, discoidal, thin and dextrally coiled; all the whorls are visible from above. Large apical part can be observed but adapical part cannot be seen because of the breakage of the specimens.

Whorls increasing in diameter rapidly and consist of two and half whorls. Body whorl larger and a little expanded around the aperture.

Remarks: The specimens under study compare with those of *Gyraulus* reported by Bhatia²⁵ from the Karewa deposits of Kashmir. However, breakage of the specimens from adapical side made their identification at species level difficult.

Order Stylommatophora
Family Chondrinidae
Genus *Gastrocopta*

Gastrocopta sp.: Referred Material: DG/PL/JU/06, one specimen. Description: Shell elongated cylindrical in outline, five whorls, whorls increase in size gradually and evenly, and moderately convex, spire higher than body whorl or nearly equal to it, apex blunt, sutures linear and impressed, aperture sub-quadrate in outline, ventral surface of body whorl convex, surface with fine longitudinal striae, apertural folds are indistinct due to matrix filling.

Remarks: *Gastrocopta* is known by *Gastrocopta kashmirensis* from the Karewa Formation of Kashmir²⁶, *Gastrocopta naidui*²⁷ and *Gastrocopta (Gastrocopta) prashadi*²² from the terrace deposits near Chandigarh. More recently, Mathur³ described additional molluscan fauna and revised earlier described ones from the Siwalik Group and terrace deposits of Himachal Pradesh, Haryana, and Punjab and provided a comprehensive account of apertural characters that can be successfully used in taxonomic classification. In overall appearance, the specimen from the Upper Siwalik beds of Jammu is comparable to *Gastrocopta kashmirensis*. Because of the indistinct nature of apertural characteristics and paucity of material, assignment of present material to *G. kashmirensis* is avoided.

Class Bivalvia
Order Unionoida
Family Unionidae
Genus *Oxyaia*

Oxyaia sp. Indet.: Referred Material: DG/PL/JU/07, single specimen with both valve. Description: The specimen is transversely ovate in outline, anterior margin broadly rounded with an antero-dorsal notch, posteriorly cuneate, dorsal gradually sloping, ventral feebly arched, convex, broadly rounded anterior end, nearly acutely pointed posterior end, antero-dorsal notch, shell moderately inflated, umbo slightly inflated, strongly inequilateral, umbo sculpture indistinct. Dimensions: Length = 7 mm, Width = 4 mm.

Remarks: The present specimen is comparable to *Oxyaia* sp. indet. earlier described by Mathur³ from the Chhoti Parch, near Chandigarh, Pinjor Formation. This species is restricted to the Pinjor Formation.

Genus *Lamellidens*

Lamellidens lewisi: Referred Material: DG/PL/JU/08, single specimen with both valve. Description: The specimen under study is transversely elongate, elliptical in shape, shell is large, surface with distinct concentric growth lines, anterior margin broad, regularly arched, posterior narrow, sharply rounded, dorsal margin gently sloping, ventral margin nearly straight, umbo broad, low, and not much inflated, with a depression, no umbonal sculpture.

Dimensions: Length = 62 mm, Width = 22 mm

Remarks: This specimen resembles *L. lewisi* described by Vokes²⁸ from the Tatrot Formation near Tatrot (Pakistan) and Pinjor Formation near Khol Tandu (section A vi), Chandigarh. Mathur³ reported similar specimens from west of Chandigarh (Pinjor Formation).

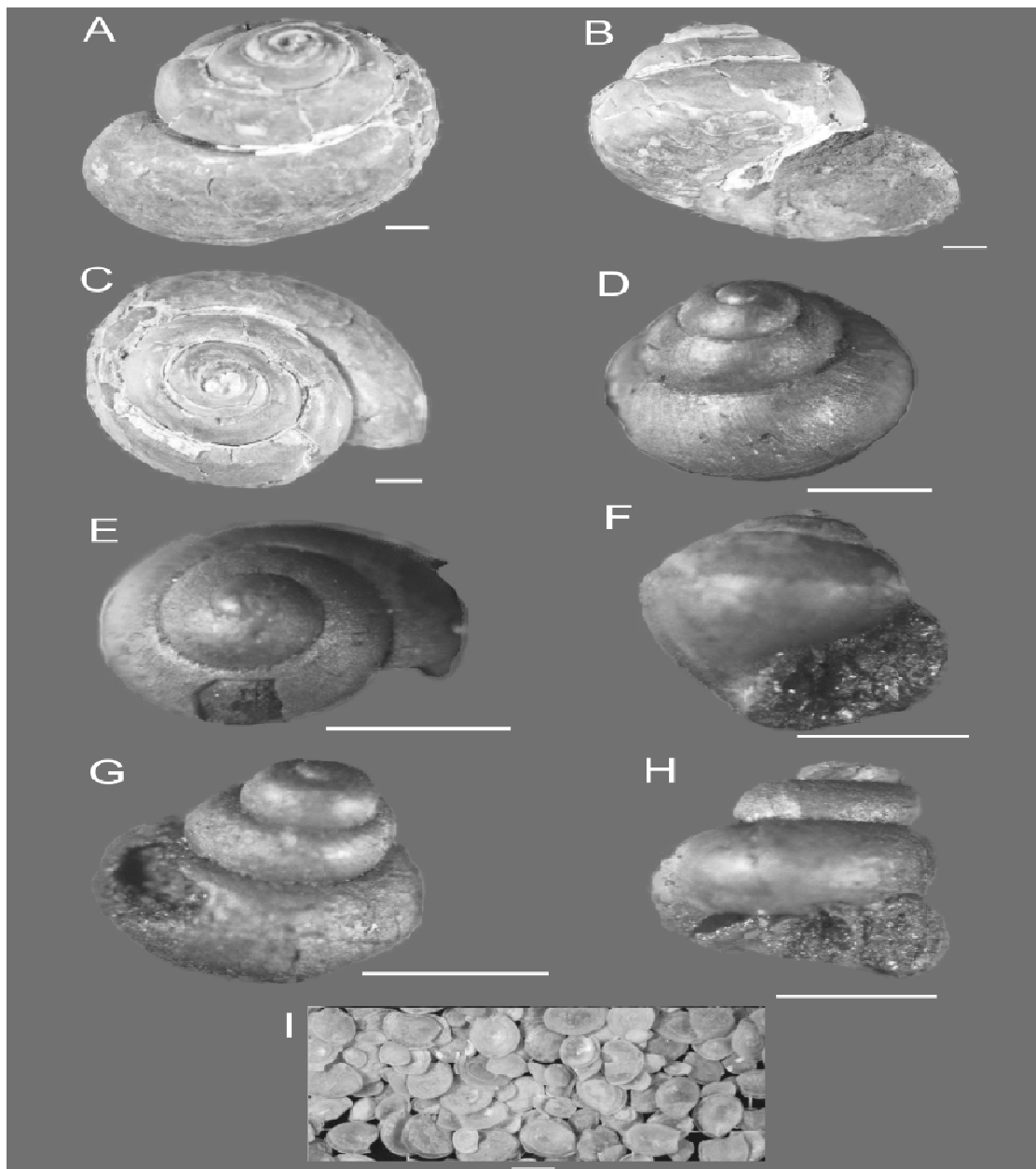


Figure-2

A. DG/PL/JU/01 *Viviparus bengalensis*; apertural view, B. DG/PL/JU/01 *Viviparus bengalensis*; apertural view, C. DG/PL/JU/01 *Viviparus bengalensis*; apical view, D. DG/PL/JU/02 *Viviparus* sp.; apertural lateral view, E. DG/PL/JU/02 *Viviparus* sp.; apical view, F. DG/PL/JU/02 *Viviparus* sp.; apertural view, G. DG/PL/JU/03 *Bellmiya celispiralis*; apertural view, H. DG/PL/JU/03 *Bellmiya celispiralis*; apical apertural view, I. DG/PL/JU/04 Opercula of indeterminate gastropods. Scale bar A, B, C, I, equals 2 mm and for D, E, F, G, H, equals 1mm

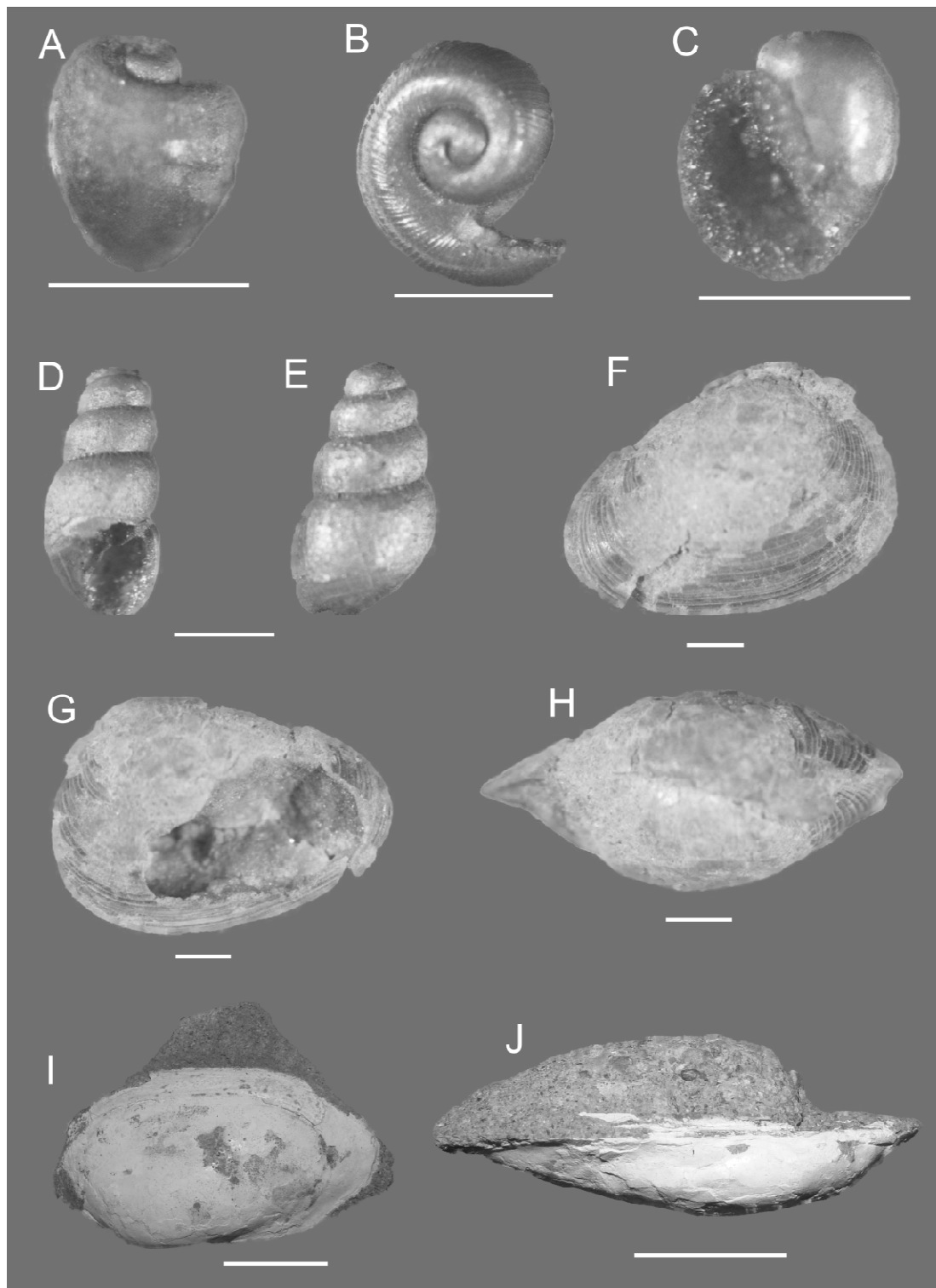


Figure-3

A. DG/PL/JU/05 *Gyraulus* sp. ; apertural view, B. DG/PL/JU/05 *Gyraulus* sp.; apical view, C. DG/PL/JU/05 *Gyraulus* sp.; apertural view, D. DG/PL/JU/06 *Gastrocopta* sp.; apertural view, E. DG/PL/JU/06 *Gastrocopta* sp.; apertural view, F. DG/PL/JU/07 *Oxyonia* sp. indet; lateral view, G. DG/PL/JU/07 *Oxyonia* sp. indet; lateral view, H. DG/PL/JU/07 *Oxyonia* sp. indet; dorsal view, I. DG/PL/JU/08 *Lamellidens lewisi*; lateral view , J. DG/PL/JU/08 *Lamellidens lewisi*; dorsal view. Scale bar A, B, C, D, E, F, G, H, equals 1mm and I, J equals 20mm

Table-1
Comparison of lithostratigraphic classification of the siwalik group of Jammu region given by different workers (modified after Prasad et al., 2005)

Subgroup	Classical subdivisions	Ranga Rao et al 1988	Agarwal et al., 1993	Gupta and Verma 1988	Gupta 2000
Upper Siwalik	Boulder Conglomerate	Boulder Conglomerate		Dughor Formation	
				Uttarbaini Formation	Marikhui Member
			Nagrota Member C		
	Pinjore Formation	Nagrota Formation	Nagrota Member B		
			Nagrota Member A		
Tatrot Formation	Parmandal Sandstone			Labli Member	
Middle Siwalik	Dhok Pathan			Mohargarh Formation	
	Nagri Formation			Dewal Formation	
Lower Siwalik	Chinji Formation			Mansar Formation	Ramnagar Member
	Kamlial Formation				Dodenal Member

Age and palaeoecology

A very few workers²⁹⁻³⁵ were carried out work on age, palaeoecology, palaeocommunity structure and Depositional environment of Upper Siwalik Subgroup of Jammu region on the basis of recovered microfossil, micro vertebrates, flora charophyte and bentonitized tuff band.

The present collection of gastropods and bivalves recovered from a mudstone horizon immediately underlying the geochronological dated (2.8±0.56 m.y.) bentonitized tuff band in association with the microfossils ostracodes (*Hemicypris megalops*, *H. pyxidata*, *Candona lacteal*, *Sclerocypris?* sp. indet., and *Cypridopsis* sp. indet., *Cypris subglobosa*, *Cypris* cf. *C. decaryi*, *Cypridopsis* sp.A, ?*Cypridopsis* sp., *Candona* sp.A, *Candona* sp.B, *Eucypris* sp.A, *Eucypris* sp.B, *Hemicypris pyxidata*, *Stenocypris major*, *Stenocypris* sp., *Zonocypris barakhetarensis* sp. nov., *Ilyocypris bradyi*, *Ilyocypris* sp., *Darwinula* sp., *Darwinula jammuensis* sp. nov., *Sclerocypris?* sp. and *Potamocypris* sp.), Charophytes (*Hornichara maslovi*, *Lychnothamnus barbatus*, *Chara contraria*, *Chara globularis globularis*, *Chara rantzieni*, *Hornichara maslovi*, *Lamprothamnium papulosum*, cf. *Lamprothamnium*, and *Lychnothamnus breviovatus* and angiospermae seeds *Boraginocarpus lakhanpalii*), Microvertebrates (*Rattus* sp., ?*Golunda kelleri*, *Golunda* sp., *Mus flynni*, *Mus* sp., cf. *Mus jacobsi*, *Millardia* sp., ? *Tatera pinjoricus*, and ?*Cremnomys blanfordi*), lizards, fishes, etc. from the Nagrota Formation of Jammu Siwalik.

The molluscs fauna recovered from the Barakhetar locality of Nagrota Formation comprises of gastropods :*Gastrocopta* sp., *Gyraulus* sp. indet., *Viviparus bengalensis*, *Viviparus* sp., *Bellamya celispiralis* and bivalves: *Lamellidens lewisi*, *Oxyaia* sp. indet.

Bellamya celispiralis is characteristic of Pleistocene-Recent sediments³. *Viviparus* is represented in the present collection by *Viviparus bengalensis* and *Viviparus* sp. *Viviparus bengalensis* was recovered from the Pleistocene of Narmada valley²¹. Bhatia and Mathur¹ recorded this species from the Pinjor Formation (Upper Siwalik) near Chhoti Parch (section A). Mathur³ also reported this species from the same locality. *Gastrocopta kashmirensis* was reported from Pliocene-Pleistocene sediments of the Karewas of Kashmir^{26, 27}. This species was also reported from Kishanpur terrace deposits³. *Gyraulus* sp. was reported from the Terrace T3 deposits of Sirsa, Kishanpura near Nalagarh (H.P.)²⁷. Tokuoaka³⁶ recovered this species from the Churia Group of Nepal. This species has also been reported from the Pinjor Formation near Chandigarh³. *Bellamya celispiralis* was reported from the Pleistocene Churia Group, West-Central Nepal.

The bivalve shells belong to *Lamellidens lewisi* and *Oxyaia* sp. indet. *Lamellidens lewisi*, originally described as an indeterminate species of genus *Lamellidens* from Asnot area (now in Pakistan)³⁷ and was later described under the trivial name *L. lewisi* from the Tatrot Formation near Tatrot (in Pakistan) and the Pinjor Formation near Khol Tandu (section A Vi), near Chandigarh²⁸. This species is known to be restricted to

the Upper Siwalik (Tatrot and Pinjor formations)²⁸. *L. lewisi* also reported from the Pinjor Formation near Khol Tandu, near Chandigarh³ and *Oxynaia* sp. indet. was recovered from Chhoti Parch, near Chandigarh³. This species is so far known only from the Pinjor Formation. Raghavan³⁸ reported this species from the Pinjor Formation of Panchkhula (Haryana, India) area.

As for as palaeoecology is concerned, majority of the taxa recovered from the Upper Siwalik strata of the studied area have living representatives or closely related forms in the living fauna. The extant molluscs are known from marine, freshwater, brackish water and terrestrial environments. They are vagrant and bottom dwellers. A few of them are burrowers in sand or mud. Most of the aquatic molluscs are preserved in situ. Contrary to this, the terrestrial fossils are commonly preserved far from their habitat. Therefore aquatic molluscs should be better indicators of aquatic ecological conditions prevailing at any time. Similarly, if changes in the type and distribution of molluscs in time and space can be evaluated, ecological variation due to changes in climate as well as topography can also be understood.

The fossil evidence for the palaeoecological inferences is derived from recovered gastropods and bivalves. Bivalves include *Lamellidens lewisi* and *Oxynaia* sp. indet. in the present collection that have wide geographical and geological distribution. The living forms are exclusively aquatic which have a range of adaptability to depth. Gastropods of the present collection include *Gastrocopta* sp., *Gyraulus* sp., *Viviparus* sp., *Viviparus bengalensis*, and *Bellamyia celispiralis*. Most of these taxa are commonly known to live in low energy environment ranging from ponds, lakes to margin of slow flowing river, but generally avoiding fast flowing waters. The exclusive occurrence of gastropods opercula indicates predominance of current action, which was not only responsible for abundant vegetative matter but also in separating the opercula from the shell and depositing them in a different part of the basin. In general, the molluscan fauna of the study area indicates freshwater, shallow lacustrine environment of deposition.

Conclusion

On the basis of gastropods and bivalves fauna in association with microfossil (ostracodes, charophytes, fishes, frogs, rodents) recovered from the mudstone horizon just below geochronologically dated bentonitized tuff band (2.8±0.56 m.y.) from Barakhetar locality, Upper Siwalik Subgroup of Jammu province, it is concluded that gastropods and bivalves bearing mudstone horizons have been deposited during Late Pliocene (Piacenzian Stage) under fresh water shallow lacustrine conditions.

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